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Motion Simulation Research Related Short Term Training Attachment to TARDEC

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ABSTRACT

In late 2011 a Land Human Scientist (LHS) from the Land Operations Division (LOD) was briefly deployed to the Tank Automotive Research Development and Engineering Centre (TARDEC) to collaborate and gain understanding of how TARDEC is effectively utilising motion simulators. TARDEC has been conducting motion simulation research in the military land vehicles domain in excess of twenty years. At the time of the deployment, LOD was in the process of building its own motion simulation capability through the purchase of a large six degree of freedom LAnd Motion Platform (LAMP). The main purpose of the training attachment was to acquire knowledge and skills with motion simulators so it could be applied to the LAMP. This document summarises the approaches taken by TARDEC with its motion simulation setup, why particular decisions were made, and makes recommendations for the LAMP.

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Executive Summary

In 2011 a Land Operations Division (LOD) member undertook a four month Short Term Training Attachment (STTA) with the US Tank Automotive Research Development and Engineering Centre (TARDEC) to acquire knowledge and skills in the area of motion simulation. At the time of deployment, LOD were in the process of installing a large six degree of freedom motion base simulator known as the LAnd Motion Platform (LAMP), while TARDEC had been using motion simulators for over twenty years in the military arena. The STTA was an opportunity to leverage off TARDEC's expertise in the area, and learn about some of the other requirements and obstacles that may lay ahead for the LAMP.

Research using motion base simulators can be broken into three major components, hardware, software, and network architecture. TARDEC has effectively mastered these three domains, and have carried out extensive research utilising their simulators. The STTA gave LOD insights into how TARDEC controls the three major components, and why particular decisions were made. It was also a chance to learn from any mistakes that were made in constructing its facilities.

TARDEC has two facilities which have motion base simulators. The bigger motion base simulator is known as the Crew Station / Turret Motion Base Simulator (CS/TMBS), and other is known as the Ride Motion Simulator (RMS). Each simulator has its own individual strengths and weaknesses and as a result, different types of experiments are conducted on each simulator. For instance, the RMS has been used to assess cupola head strikes, and the CS/TMBS has been used to do turret testing. Since LOD is in its early stages of motion simulation research (in terms of setting up motion simulation equipment), an understanding of these can lead to better decisions for LOD in the future. For example, utilising the most effective software available will ensure simulation realism. Similarly, an optimum network architecture will yield seamless integration between the hardware and software. Maintaining a close relationship with TARDEC will facilitate motion data exchanges that may reap savings and be of benefit to both the US and Australia.

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Acronyms

3D	Three Dimensional
3DOF	Three Degrees of Freedom
6DOF	Six Degrees of Freedom
ARL	Army Research Laboratory
ADF	Australian Defence Force
BMS	Battle Management System
C2	Command and Control
CASSI	Concepts, Analysis, Systems, Simulation and Integration
COTS	Commercial off the Shelf
CS/TMBS	Crew Station / Turret Motion Base Simulator
DSTO	Defence Science and Technology Organisation
DT877	Defence Trial 877
E-stops	Emergency stops
EEG	Electroencephalography
GUI	Graphical User Interface
GVSL	Ground Vehicles Simulation Laboratory
HRED	Human Research and Engineering Directorate
IMPRINT	Improved Performance Research Integration Tool
IVE	Immersive Virtual Environment
LHS	Land Human Scientist
LAMP	LAnd Motion Platform
LOD	Land Operations Division
MBT	Motion Base Technologies
MRAP	Mine Resistant Ambush Protected
RMS	Ride Motion Simulator
RTI	Realtime Technologies Incorporated
SA	Situational Awareness
SDU	Smart Display Unit
STTA	Short Term Training Attachment
TARDEC	Tank Automotive Research Development and Engineering Center
TCP	Transmission Control Protocol
TMBS	Turret Motion Base Simulator
UDP	User Datagram Protocol
US	United States
VE&A	Vehicle Electronics and Architecture
VICTORY	Vehicular Integration for Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance/Electronic Warfare (C4ISR/EW) Interoperability

Glossary

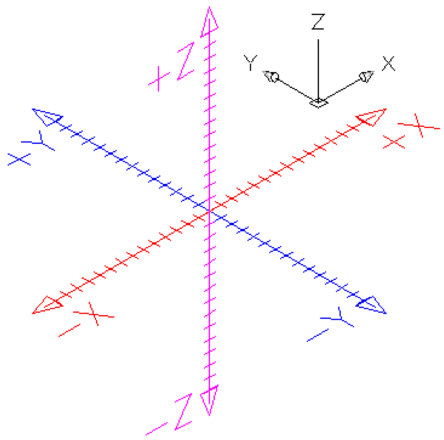
Degrees of Freedom (DOF): The number of independent movements the simulator can produce through the actuators. This can be either translational or rotational movements.

Frequency Bandwidth: The frequency window which the simulator is capable of producing. For example, a 25 Hz frequency bandwidth would mean the simulator could change direction 25 times in one second.

Gigabit: A bit is a binary digit, which can either be a zero or a one. A gigabit is one billion bits. The transmission of one billion bits in one second is known as a Gigabit Ethernet.

Hertz (Hz): The International Standard (SI) unit of frequency. In the context of motion simulation, it is equal to the number of changes in direction on a particular axis. For instance, a maximum 25 Hz in the z-axis means, the simulator is capable of changing the up and down movement a total of 25 times in one second.

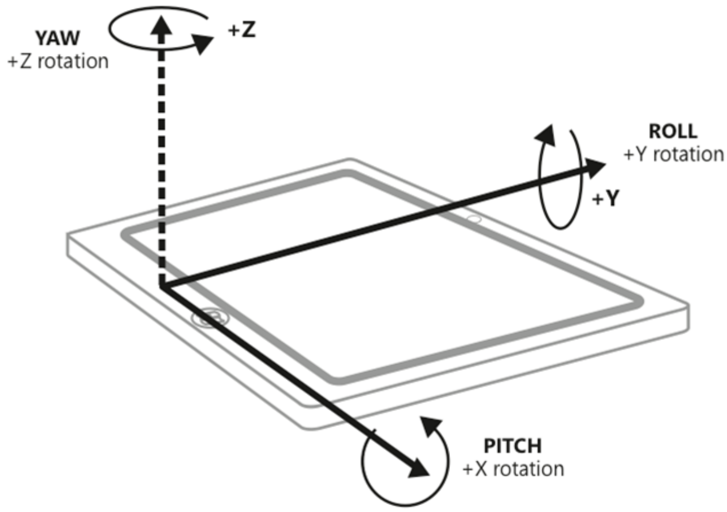
Linear (Translational) Axes: Three-dimensional ordered triplet of lines (axes) (Figure 11). Any two lines in the system are perpendicular. The movement along any one axis constitutes a degree of freedom. Moving up and down (along the z-axis) is commonly known as heave, moving left and right (along the x-axis) is commonly known as sway, and moving forward and backward (along the y-axis) is commonly known as surge.



Source: http://www.we-r-here.com/cad_08/tutorials/level_3/3-3.htm

Motion Simulator: A mechanical system that allows it's occupants to experience the effects and feelings of being subjected to movements inside a vehicle. A motion simulator is also commonly known as a motion base or motion seat. Motion simulators are often synchronised with visual, audio and tactical elements for a greater immersive experience.

Rotational Axes: The circular movement around one of the linear axes (Figure 12). The rotation around the z-axis is commonly known as yaw, the rotation around the x-axis is commonly known as pitch, and the rotation around the y-axis is commonly known as roll.



Source: http://blogs.msdn.com/b/b8/archive/2012/01/24/supporting-sensors-in-windows-8.aspx

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1. Purpose of Short Term Attachment

The aim of the four month (August – November 2011) Short Term Training Attachment (STTA) to the US Tank Automotive Research Development and Engineering Centre (TARDEC) was to gain knowledge and skills with motion simulators. It was an opportunity to receive training and obtain an understanding of how to pertinently use motion simulators. The idea was to leverage off TARDEC's vast experience in this field. It was an opportunity to examine the setup of TARDEC's simulators, the hardware is being used, the software being run to create the scenarios and the network architecture that are in place. The purpose was to use these observations to help aid in the design and setup Land Operation Divisions' (LOD) LAnd Motion Platform (LAMP).

The STTA was placed within the Research and Technology Integration division of TARDEC. The Research and Technology Integration has six groups within the division. The STTA was within the Concepts, Analysis, Systems & Integration (CASSI) group. The CASSI group is involved with many aspects of simulation, ranging from physical vehicular testing to motion simulation to modelling and simulation. The main liaison for the STTA was Mr. Harry Zywoil, who was the team lead for the motion simulation research area known as Motion Base Technologies (MBT) within the CASSI group. The MBT team was responsible for maintaining and operating both of the motion simulators at TARDEC. The MBT team was responsible for setting up the simulation scenarios on the motion simulators and carrying out the relevant experiments. The STTA provided an opportunity to observe first hand how simulation was run and the type of experiments that could be run.

The secondary purpose of the visit was to continue the strong links that TARDEC and the Defence Science and Technology Organisation (DSTO). In November 2010, DSTO and TARDEC ran a joint multi-national robotics competition known as the 2010 Multi Autonomous Ground-Robotics International Challenge (MAGIC 2010). The competition is a testament to the common research goals that both organisations share. The MAGIC 2010 competition merely highlights one area of overlap, as there are many others. In particular, the motion simulation domain is of specific interest to both organisations. Each organisation has its own strengths in this area. Thus the idea is to foster collaboration in this space to help each organisation optimise the outcome of their research goals, and where possible, share data from experimental activities.

2. Background

This section aims to provide a background overview of why the motion simulation research related STTA (August to November 2011) to TARDEC was originally proposed by the LOD. LOD provides scientific leadership and support to the Land Force through structured and analytical approaches to capability development. LOD is responsible for helping the Army better complete their missions. The Background Section will discuss issues which relate to why the STTA was proposed, and context under which the attachment took place. The TARDEC Structure Section will outline the TARDEC's overall function as an organisation. Section Four – Motion Based Technologies Laboratory will discuss the technical details of the STTA, and offer recommendations for LOD. Lastly, the Other Agenda Section will outline additional areas of mutual interest between DSTO and TARDEC.

2.1 Land 121 (Project Overlander)

Land 121 (Project Overlander) is a major Australian Defence project aimed at delivering field vehicles and trailers. The future vehicles are to replace the existing fleets. As part of the project there is a requirement for DSTO to look at the human factors issues of soldier performance within military vehicles. This requirement states that there are extensive demands on soldiers inside a vehicle such as driving, navigating, communicating, acquiring targets, whilst at the same time maintaining situational awareness. However, the working environment inside a cabin is quite harsh due to the threat of enemies, motion, limited cabin space, etc. These conditions can easily lead humans to reach their physical and cognitive limits. Although, these issues must have been considered for the current and previous field vehicles, new demands are being placed on humans with the introduction of L121 vehicles. The transition from maps/radios to screens, boards and data, represents a new requirement for future new activities in vehicles.

Hence there is a need to understand how motion affects human performance, particularly how it affects military orientated tasks (e.g. BMS usability tasks). If the limits of humans are known in this space, then the expectations upon soldiers can be managed. To address these issues, LOD developed a simulation laboratory which currently consists of two motion simulators, which are the LAnd Motion Platform (LAMP) and the Human In Vehicle Integration Capability (HIVIC). These simulators are both capable of evaluating human performance under motion.

2.2 LAMP

The LAMP is a large scale six degree of freedom motion platform which can simulate various vehicle types to assess the impact of motion on the vehicle occupants while using Command and Control (C2) systems. It is capable of producing realistic motion similar to what soldiers would experience in the field. Hence, it provides a safe environment which allows for dangerous situations to be simulated. The performance of soldiers as result of being put into these situations can then be analysed.

The LAMP allows various neuro-psychology, systems usability, crew workload and other human factors related experiments to be conducted under motion. For example, crews can be placed in a scenario where they are ambushed by enemies, and the decisions they make, their team dynamics, and planning can be evaluated. Similarly, vehicle subsystems (e.g. BMS) can be placed inside the cabin while it is subjected to motion, and the usability under typical military vehicle motion can be assessed.

2.3 TARDEC's Simulation Expertise

TARDEC has a vast motion simulation experience. TARDEC has been conducting motion simulation research for over twenty years in the military domain. TARDEC has a dedicated simulation laboratory known as the Ground Vehicle Simulation Laboratory (GVSL). The GVSL has two dedicated motion base simulators with different capabilities. Both simulators are six degree of freedom systems with varying performance specifications (details below).

3. TARDEC Structure

TARDEC was established in 1946, just after World War II. At that time TARDEC was known as the Tank Components Laboratory, and its sole purpose was to build quality tanks. TARDEC has since grown into one of America's leading ground vehicles research organisations. TARDEC is located in Warren, Michigan, amongst some of the biggest automotive companies in the United States. It currently has around 1,500 staff, and an annual budget of approximately $500 million.

TARDEC's main aim is to deliver advanced technology solutions for the American Defence ground vehicles. Its mission is to develop, integrate and sustain the right technology for manned and unmanned American Department of Defence ground systems. It has four key roles, which are to lead, innovate, integrate, and deliver. TARDEC strives to lead by taking initiative, drive change, and make good decisions for the warfighters. It wants to be innovative by creating opportunities where none existed before. TARDEC strives to be the lead for ground systems integration for the American Department of Defence. This can be seen with programs such as the VICTORY architecture, a common standard for all vehicle electronics. Finally, TARDEC aims to deliver technology solutions to the soldiers quickly.

3.1 TARDEC Organisational Chart

Figure 1 shows TARDEC's organisational chart. TARDEC has four major divisions, which are, Robotics, Research and Technology Integration, Product Development, and Engineering. The LOD LHS was placed within Concepts, Analysis, Systems, Simulation & Integration (CASSI) group which is part of the Research and Technology Integration Division. At the time of the STTA, the director for the Research and Technology Integration Division was Ms. Jennifer Hitchcock. The CASSI group is involved with many aspects of simulation ranging from physical systems testing to motion simulators to creating virtual battlefields for soldiers.

The CASSI group has five main areas of focus, which are, ground vehicle power and mobility, vehicle electronics and architecture, intelligent ground systems, ground system survivability, and force projection technology. The group captures the Army's requirements, develops concepts, and formulates programs to answer and address Army's questions. The CASSI team carries out dynamic and structural performance tests, create mathematical models, and analyses the data. The group also conducts physical and systems level validation of the data.

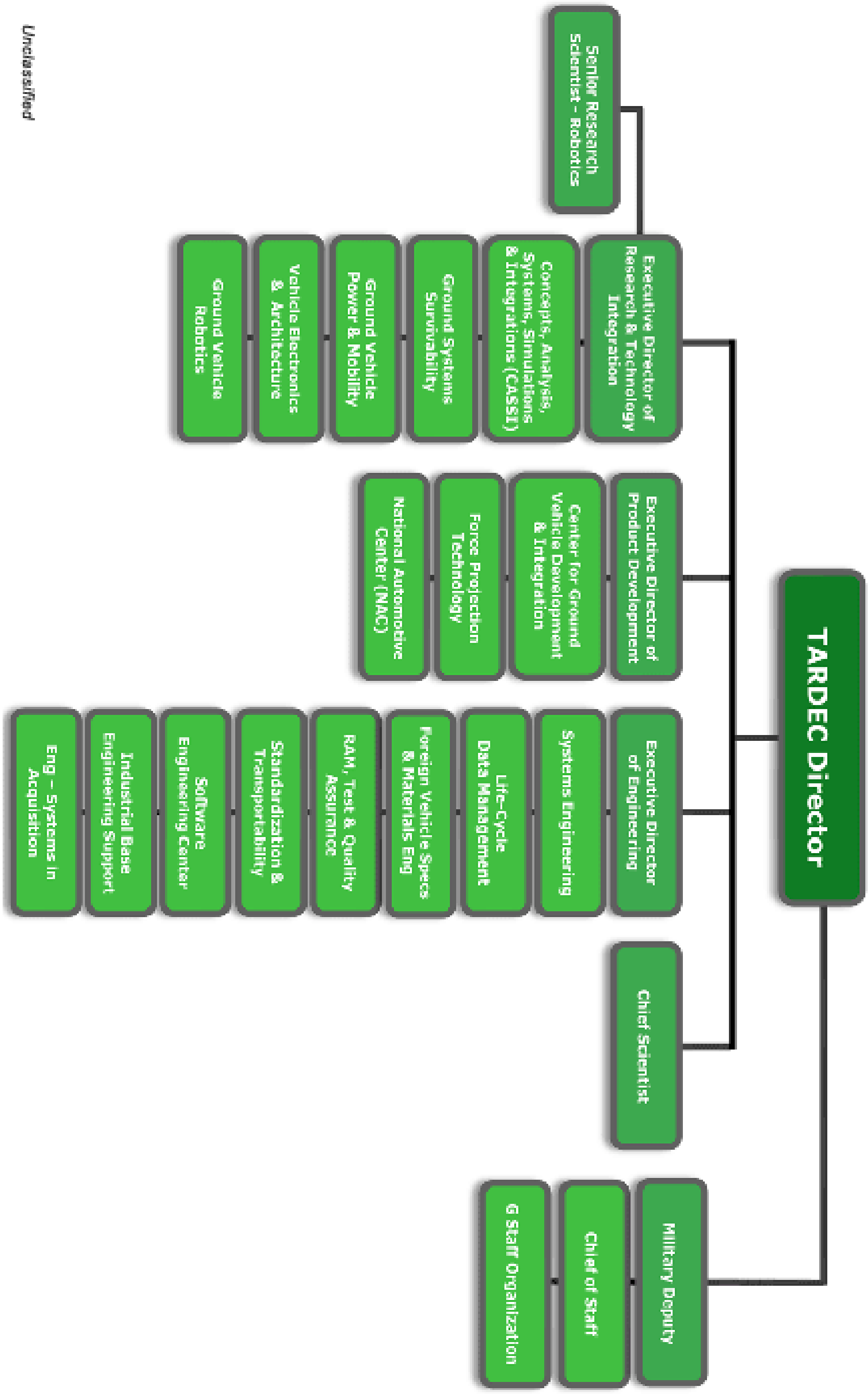

Figure 1: TARDEC Organisational Chart

Source: http://tardec.army.mil/about/organization.aspx. Retrieved March 28, 2012.

4. Motion Base Technologies Laboratory

During the STTA, the LHS worked in the Motion Base Technologies (MBT) laboratory, which is a team within the CASSI group. The MBT team has around 13 full time staff members dedicated to human in the loop simulation research. During the attachment there was an opportunity to work closely with most of the staff in this group. The team's role is to create realistic simulation scenarios and carry out experiments. The team is in charge of managing, maintaining and running the two motion base simulators. It was interesting that the MBT team is not always required to analyse the experimental data collected from the simulators. Other defence clients often take the experimental data and analyse them.

After the completion of an experiment the MBT team would internally analyse their performance. They also sought external feedback as to how well they did in creating the simulation scenario and the improvements that could be made in the future.

4.1 Hardware

TARDEC has two motion base simulators which are currently being used for human in the loop experiments. This section will highlight the strengths and limitations of the two simulators. It will also discuss some critical questions which were answered before the acquisition of the simulators, relating to the how, what, why, scope, risks and benefits. That is, how the simulator was put together, what the simulator can do, why that particular simulator was chosen, the scope of each simulator, the risks associated with the purchase, and the benefits to the organisation by having this technology.

Common to both simulators is the tuning. Each simulator is tuned after the fixed payload (cabin and any other significantly heavy equipment) has been put on top of the motion base. The tuning is done by inputting random white noise into the simulator and seeing how well the output matches a given input. It is done in two domains, using oil pressure, and in the frequency domain. The oil pressure input must match the output pressure. The frequency graph should be at 0 dB for as long as possible, before trailing off. This will give the largest bandwidth, and most realistic motions. For example the graph in Figure 2 has a bandwidth of around about 80 Hz.

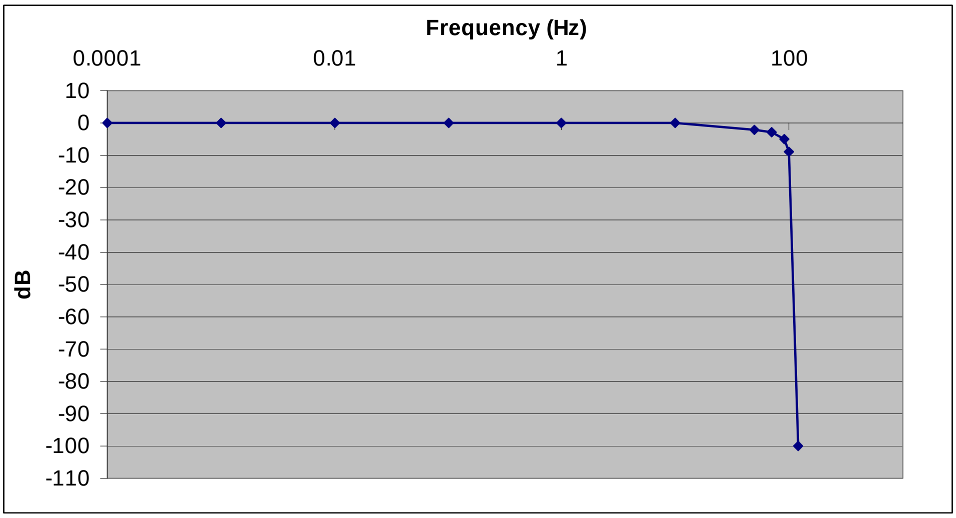

Figure 2: Theoretical frequency output to white noise input after tuning a simulator

4.1.1 CS/TMBS

The biggest motion base simulator that TARDEC has is known as the Crew Station / Turret Motion Base Simulator (CS/TMBS). This simulator was acquired in the mid 1980s, when motion simulators were in their infancy. The original contractor for the CS/TMBS defaulted on their contract. The contractor had completed all the design work, but then became financially bereft. Thus they were able to provide all the parts and components but not finish the setup and installation. TARDEC then put all the parts together themselves.

Originally, this simulator was designed to do turret stabilisation testing, as seen in the Figure 3. The turret was placed under vibrations it would typically experience in the field and the test was to track a particular target point. At that time, it was simply known as the Turret Motion Base Simulator (TMBS). It has the capability to carry a very large payload of up to 25 tonnes. It was a one of its kind, and is still today considered a very high payload carrying motion base. Its strength lies in being able to simulate situations that require a high weight capability.

Figure 3: Turret Motion Base Simulator

Source: http://www.tardec.info/GVSETNews/article.cfm?iID=0603&aid=01. Retrieved March 23, 2012. Picture taken in 2008.

The TMBS was developed because there was no other simulator like that at that time. Its ability to carry the high payloads such as turrets made it a unique tool. The performance and capacity requirements of turret simulation required a heavy duty ruggedised motion base which the TMBS offered. The design is capable of carrying an active Abram class turret. Since it was not designed for driving simulation it has several disadvantages in that domain. The lag time and washout algorithms sometimes are not capable of delivering fast, tight manoeuvres. If it had been foreseen that crew simulation had to be done in the future, perhaps a different choice would have been made. A simulator capable for the turret simulation but also more suitable for the driving would have been considered.

The simulator is versatile, and after the turret tests were over, it was converted into a crew station motion base simulator for human in the loop experiments which can been seen in Figure 4. The picture is a little dated, because the actual cabin is now fully enclosed. After the conversion, the name of the simulator changed to CS/TMBS. Hence, the scope of the CS/TMBS is large, but for different types of simulations. Its fidelity may be lower than for other simulators due to sluggish response times and limited movements that it can produce. However, it does have the benefit of being able to simulate a four person crew at one time. Research areas which require a crew to be analysed can be explored using the CS/TMBS. The visuals inside the simulator are displayed using three projectors which are mounted to the ceiling inside the cabin. The projectors display images to a curved screen in the foreground, which gives approximately a 200 degree field of view. There are also side mirrors on both the driver's and front passenger's side. It was relatively easy to change the top of the base and bolt down the crew cabin. Similarly, the current cabin can be replaced with any other requirement that TARDEC may have.

Figure 4: Crew Station / Turret Motion Base Simulator (CS/TMBS)

Source: http://www.tardec.info/GVSETNews/images/060413_photo2.jpg. Retrieved January 7 2013.

There were some risks associated with the acquisition of the CS/TMBS. Since simulators were rare at the time of procurement, there was a concern regarding the performance specifications given by the manufacturer. For instance, if the payload capacity was not accurate, it would have defeated the whole purpose of the acquisition. There were also risks associated to being able to find clients and funding for research to be carried out using the simulator. The MBT team had to ensure that they could show the value of this advanced technology to its clients, rather than the clients perceiving it as an experimental piece of the equipment in its developmental stages. Also, without the necessary funding, the simulator would be under utilised.

Acquiring the CS/TMBS has benefited the organisation far beyond its original intent. Without the simulator, there wouldn't be the capability for some of the recent projects that TARDEC is looking at. There have been many after the fact projects as a benefit of having the capability. There was a lot of project ideas which were not envisaged at the time of purchasing, but this type of technology, with such capability and versatility, allows it be utilised for other types of unforeseeable projects.

4.1.2 RMS

The other simulator which TARDEC has is known as the Ride Motion Simulator (RMS), and is smaller than the CS/TMBS. However, its smaller size actually leads to many advantages over the CS/TMBS. The RMS is a single-seat simulator, and has historically been used for neuro-psychology experiments. Again, the cabin is interchangeable, and can be set up for the requirements of the experiment. Figure 5 roughly shows what the current cabin setup looks like. Appendix A shows some other photos of the RMS during experiments.

Figure 5: Ride Motion Simulator (RMS)

Source: http://www.sae.org/servlets/dlymags/dailymag/articleImage.jsp?imgsrc=/dlymagazineimages/10665_13249_ACT.jpg&alttxt=Fig1.jpg. Retrieved January 7 2013.

The RMS was fully designed and assembled by a contractor. When the TMBS was built TARDEC was able to put all the parts together themselves. This leads to the question, why TARDEC did not choose to assemble the RMS internally. It is because the organisation had evolved. When the TMBS was built (mid 80s) TARDEC had the practical expertise to put the simulator together. However, by the time the RMS was purchased (1997) TARDEC no longer had that expertise.

The RMS is a servo hydraulic simulator as opposed to an electric actuator. It is capable of producing fast manoeuvres unlike the TMBS. It is able to re-create high frequency motion up to a 3g acceleration capacity. It was designed originally to simulate ride in European based tank battles. It was bought to overcome the limitations of the CS/TMBS. It is best for vehicle touring, and any experiment which only requires one participant to be tested at a time. It can re-create very realistic simulations in an immersive environment. This is because it is a single seat configuration, hence all of the focus is on that single occupant and the visual, audio and motion cues can all be optimised for that one person. The visuals for the RMS are displayed by three monitors in front of the participant. Due to its smaller cabin interior, it was determined that projectors would not be suitable for the RMS.

The cabin of the RMS has can be easily re-configurable to mock up almost any type of military vehicle cabin. It was fortunate that at the time of acquisition there was a need for the cabin to be re-designable. This is now proving to be very beneficial. The interior panels, switches, control, steering as well as seats can all be changed to mock the necessary vehicle. Originally it was designed for a High Mobility Multipurpose Wheeled Vehicle (more commonly known as a Humvee) cab.

Similar sorts of risks were faced with the RMS as with the CS/TMBS, particularly, finding clients and maintaining funding. But as with the CS/TMBS the benefits have outweighed the risks that were taken. The RMS has been used for a wide range applications, some of which were not anticipated in the beginning.

4.1.3 Performance Specifications

Each of the TARDEC simulators, and the DSTO LAMP has its own strengths and weaknesses. Table 1 lists some of the critical parameters of simulators and shows how these parameters compare amongst the simulators. Some parameters for the CS/TMBS were not available, and thus the table is not complete.

Table 1: Performance specifications of the CS/TMBS, RMS and LAMP

Maximum Performance Specs	**CS/TMBS**	**RMS**	**LAMP**
Linear Displacement (cm)	+/-75	+/-50	±57 (x), ±49 (y), ±39 (z)
Angular Displacement (degrees)	+/-20	+/-20	±24 (y), ±28 (x & z)
Linear Velocity (m/s)	2	0.8 (x & y), 1.3 (z)	0.7 (x & y), 0.5 (z)
Angular Velocity (degrees/s)		70 (x & y), 90 (z)	~ 35
Linear Acceleration (g)		1 (x & y), 2 (z)	0.71 (x & y), 1.02 (z)
Angular Acceleration (degrees/s^2)		1146	225
Bandwidth (Hz)	5 (x & y), 10 (z)	40 (z)	25
Payload (Tons)	25	1	2.8

In terms of size, the CS/TMBS is the largest amongst the three. It is able to produce the longest linear displacement through its larger actuators, and has the highest payload capacity. The angular displacements for all three simulators are somewhat similar. The CS/TMBS has the largest linear velocity capability, followed by the RMS and then the LAMP. The angular velocity of the LAMP is more than half that of the RMS in the x and y axes and almost three times lower in the z axis. The linear and angular velocities shape how quickly manoeuvres can be completed whilst driving. For example, the LAMP would not be as capable of producing tight, fast steering manoeuvres compared to the RMS.

The maximum linear acceleration is almost one third slower for the LAMP in the x and y axes, and twice as slow in the z axis compared to the RMS. The angular acceleration is approximately four times quicker in the RMS compared to the LAMP. The linear and angular accelerations determine how quickly the speed and direction the actuators can change. Unlike a racing car, in the military vehicle domain, this parameter is less relevant compared to some of the others.

The bandwidth is an important factor for motion simulators. The CS/TMBS can simulate motion within the 10 Hz frequency in the z axis, and only 5 Hz in the x and y axes. The RMS can simulate 40 Hz, and the LAMP can achieve 25 Hz. The bandwidth controls how well jerky rough motion can be replicated. In the military context this can be critical because soldiers are often expected to drive off road when deployed in the real world. The Australian and International whole body vibration standards (AS 2670 1–2001) weigh the frequencies between 0.1 Hz and 40 Hz relatively highly. This range of vibration frequencies have been determined to have a substantial impact on the human body. Hence, it is important for a simulator to be able to reproduce that range of frequencies.

4.2 Software and Network Setup

TARDEC has opted to use a modular architecture to their software setup, as opposed to a single program which fulfils all software needs. The flowchart in Figure 6 shows the current software setup for both the CS/TMBS and the RMS. All the software used in the simulators are commercial off the shelf (COTS) products. TARDEC had used other defence and military software in the past, but ran into too many compatibility and usability problems. Arguably, motion simulators are unique and separate from other simulation environments such the IVE. Hence, they require software that can handle the needs of the motion base. The MBT team has also found the COTS softwares to be more user-friendly.

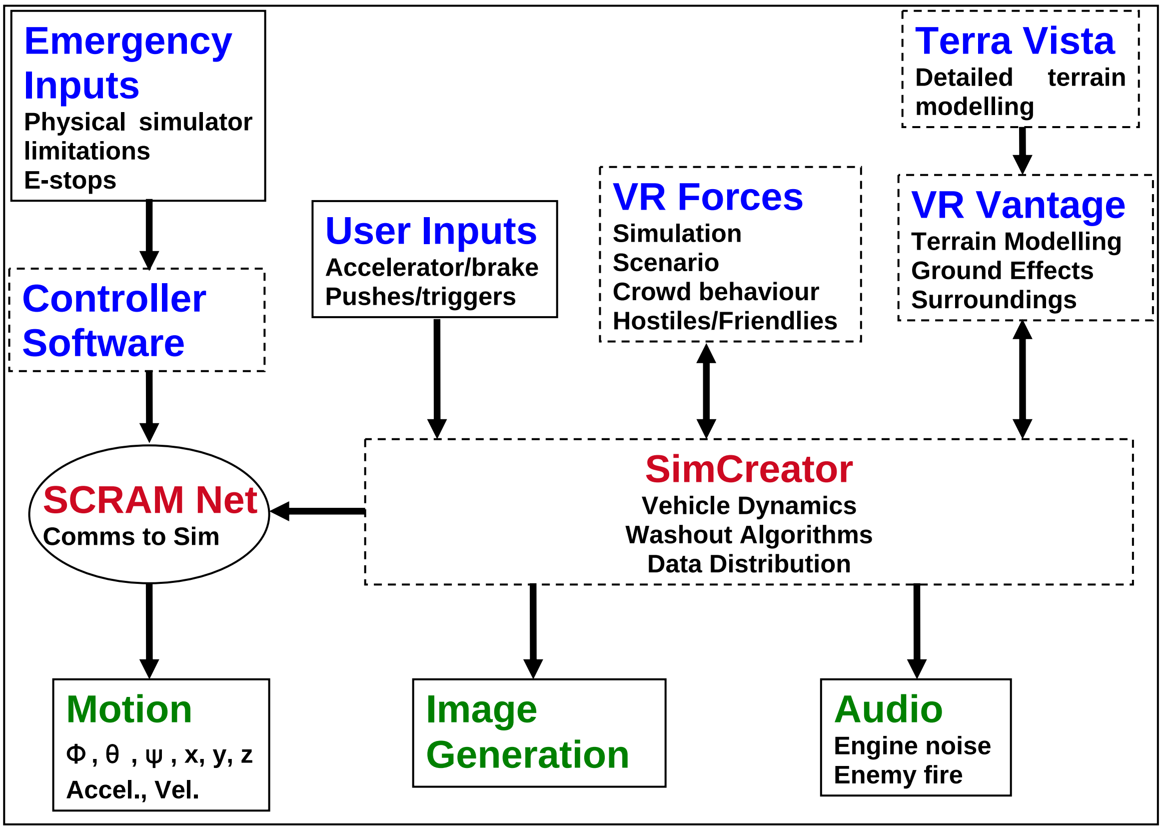

Figure 6: TARDEC's Software Setup for motion based simulators. Blue indicates inputs, red indicates data processing, and green indicates outputs. The dashed boxes indicate the software, and non-dashed boxes indicate physical systems. The oval box represents the network via which the motion base is controlled.

TARDEC is using a program called VR Forces to generate the simulation scenario. It sets in place trigger points for events to occur. For example, a participant can be driving along, and cross a particular checkout or building of interest, and then enemies might appear. VR Forces also controls the general population crowd behaviour and the behaviour of hostile and friendly forces on the map. In the past TARDEC has used other software such as OneSAF Test Bed (OTB) and OneSAF Objective System (OOS) to create the simulation scenarios.

VR Vantage is being used to model the terrain and ground effects. For a more detailed level of terrain modelling a separate software known as Terra Vista is used. Another software that was used in the past was Delta 3D. The terrain models are all based on polygons which can be modified to suit the correct ground model requirements. VR Vantage gives an initial ground model but contains large polygons. Its strength lies in being able to produce a large terrain database quickly. It was found that, detailed terrain modelling such as removing big bumps on the road, was more easily done on with Terra Vista than with VR Vantage. Gravel effects, and soft soil effects are also easier to do on Terra Vista. Hence, VR Vantage and Terra Vista complement each other for the overall terrain model.

As can be seen in Figure 6, the centrepiece of TARDEC's software setup for the motion simulators is a program called SimCreator. SimCreator is a programming language, similar to that of SimuLink. SimCreator is responsible for bringing together all pieces of data and distributing them to the relevant computers. For instance, it will detect user inputs such as accelerations or braking, and combine it with aspects such as the current terrain over which the vehicle is travelling, the speed of the vehicle and any ground effects. It also does all the vehicle dynamics and washout algorithms and integrates all these components to give the right motion signal to the motion base.

SimCreator also sends out information to the projectors inside the CS/TMBS or the screens on the RMS. It is responsible for the image generation, and making sure the right view is transmitted to the right screen. Audio is also exported via this program. It does this data distribution through Ethernet connections over a UDP (User Datagram Protocol) protocol to all the different computers. Unlike TCP (Transmission Control Protocol), UDP connections do not have an error checking protocol. However, UDP is faster, and because it was important to get the data quickly over to the relevant machines, UDP connection was chosen. The MBT team has not run into any problems using the UDP protocol. In fact, they have even run experiments remotely in Florida from Michigan over UDP connections, without any errors.

A separate software, known as the Controller Software sits outside the main software setup. It controls the emergency stop (E-stops) buttons, and the physical simulator limitations. Whoever designs the controller software, usually also designs the E-stops. This is because the E-stops need to work in unison with the controller. That is, when a person hits the E-stop, the controller software needs to be able to stop the simulator. This software is isolated from the main setup so that it does not get affected by any glitches within the main setup. Physical limitations are also imposed on the simulator, as it may not be desirable to push a simulator right to the edge of its capacity. For insistence, 90% of the actuator limit may be more than sufficient for experiments.

Lastly, the actual motion parameters sent to the simulator is done via a system known as SCRAMNet. SCRAMNet filters the data so that it can run the motion base. For example, SimCreator outputs data at 100 Hz, but the motion base can only accept data at 20 Hz. SCRAMNet is designed to read off data in a shared memory network. It sends the data in the correct format and protocol which are understood by the motion base. It can both record and stream data in real time. SCRAMNet has a user GUI (graphical user interface) which one of the MBT staff controls. The GUI displays properties such as x, y, z positions, roll, pitch, yaw recordings, oil pressure, temperature and many other readings. It has an option to run locally or on the network. During experiments it needs to be run on a network, since it needs to take inputs from several different computers. However, SCRAMNet is a fairly old motion simulation technology and can only handle data at 100 MB/s. In fact TARDEC is going to replace this system with a Gigabit Ethernet network.

4.3 Team Roles

The MBT team is fairly large in terms of staff dedicated to one specific area of research. Table 2 shows roles of each of the team members within the MBT team. There is a total of 13 staff members dedicated to human in the loop simulation.

Table 2: Team Member Roles

Role	Assigned Personnel
Manager	1
Experiment Supervisor	1
Control / Safety commander	1
Scenario Developers	2
Terrain Modellers	2
Vehicles Dynamists *	3
Hardware Experts	2
Psycho-physiologist	1

** These members are either contractors or other members of TARDEC. They are not permanent members of the MBT team, but during experiments they are essential to the team makeup.*

There is one team manager who ensures communication flows between the team, the client and higher level TARDEC management. The experiment supervisor overlooks the day to day goals of the teams. One person is assigned as the safety, ethics, and control software officer. There are two people who created the scenario and the environment for each experiment. They set trigger points for events to occur, introduce hostile and friendly forces, as well trees, houses, and other visual effects. They research the environment that are modelled and try to make the visual effects as realistic as possible. For example, after one of the experiments, soldiers (recently deployed) gave feedback saying there were not enough motorcyclists in the urban terrain that was modelled. The scenario developers utilised that feedback and started modelling motorcyclists for their next experiment.

Two people are dedicated to modelling the terrain, and make sure that the simulator does not reach physical limits due to terrain black spots. Terrain black spots occur when a vehicle goes over a particular spot in the simulation and it causes the motion base to go into an E-stop mode. The simulator could easily go into an E-stop mode if the vehicle was driven over a bump that is too steep or if there are errors in the polygons of the terrain database. The terrain modellers test the database outside of the motion simulator, and fix those bugs that can cause problems for the motion base.

The three vehicle dynamists are either contractors or internal TARDEC dynamics specialists from another group. This is because vehicle dynamics modelling is a highly skilled job, which requires people with a technical background and sufficient experience. The MBT team does not have such a specialist within its team because dynamists are required in other parts of the organisation and they are easily accessible through contractors. The dynamists embed vehicle performance characteristics such as suspension parameters, vehicle dimensions, braking/acceleration profiles and others into the software.

There are a couple of people responsible for putting in hardware to the cabin. For example, in one of the experiments side mirrors for the cabin had to be installed, and a particular subsystem (ruggedised computer) had to be fitted in the cabin which was being tested. Each experiment had slightly different hardware requirements, and team members ensured everything was integrated properly with other existing equipment. Lastly, there is one psycho-physiologist who places all neuropsychology equipment such EEG (electroencephalography) systems, eye trackers, and any others that were required on the participant.

The contacts for each team member as at December 1, 2011, as well as other contact details can be found in Appendix B.

4.4 End User Experiments

Throughout the attachment there were two end user experiments that were conducted. It was good to be able to see first hand the type of research questions that could be answered using the simulators. It was valuable to observe the problems that arose during the experiments, and the way they were overcome. This section summarises those end user experiments.

4.4.1 360 degree Situational Awareness

The first experiment that was observed was the 360 degree Situational Awareness (360 SA) experiment. The aim of the experiment was to evaluate a new 360 degree video monitoring system. In the real world the vehicle would be mounted with cameras on various points of the roof, which would enhance the soldier's awareness of their surroundings. The CS/TMBS was used for this experiment and as shown in Figure 7, the Smart Display Unit (SDU) that would be installed in the vehicles was mounted inside the cabin. The SDU was receiving the video feeds from the point of view of where the actual cameras would be mounted.

Figure 7: Smart Display Unit

Experienced soldiers, with very recent field exposure were brought in for the experiment. There was one driver, one commander, and one gunner. The commander was in charge of the SDU. In the experiment, there were three scenarios which the soldiers had to drive. One mission had no obstacles, and was a peaceful drive. Another mission required the soldiers to divert from the assigned route and help other allies by providing support. And in the third mission the soldiers were ambushed whilst on route to a village. Whilst the soldiers were driving on their missions, the commander was constantly looking out for enemies in their vicinities through the SDU.

After completing each mission, an after action review was conducted and the soldiers were asked to give some feedback of how they thought the SDU helped or hindered their mission. DSTO had contributed in shaping some of the after action review questions. Nicole Fergusson and Carolyn Chadunow had sent some of the survey questions that were used in the DT877 (Defence Trial 877) for vehicle usability. The DT877 survey contained questions which were not initially considered in the 360 SA experiment, but proved to be very relevant in terms of the type of feedback the TARDEC team was looking for. Even though the DT877 trial aimed at evaluating the usability of military vehicles, whereas the 360 SA experiment looked at the usability of a new video monitoring system, the ultimate goal of each was to analyse whether new technology would be well received within the respective armies. That is why the questions were common to both research areas.

TARDEC's main role in this experiment was to have an accurate depiction of the terrain, as well as model an MRAP (Mine Resistant Ambush Protected) vehicle. The client, which was a different Defence organisation was responsible for collating the driver feedback and report the findings. In order to deliver a superior simulation environment, some obstacles had to be overcome.

There were a lot of places where the terrain polygons were not small enough. This had led to the vehicle rolling over in those spots, or undergoing some strange behaviour. The terrain modellers had to work hard to smooth out those areas, and make sure the vehicle performed properly. There were administrative delays with the hardware. The side mirrors, which were required for this experiment, were not delivered on time. Once they actually arrived the staff had to work diligently to ensure the project ran to schedule. Another obstacle actually occurred during the start of the first experiment run. Several of the soldiers had indicated that the vehicle was not accelerating as quickly as MRAP vehicle should. Internal TARDEC dynamists were called in to check the vehicle properties. They ensured that the calculations were correct. The team then discovered that the vehicle was actually stuck in a lower gear, which prevented the normal acceleration. This was easily fixed through software parameter changes.

4.4.2 Fatigue Study

The other experiment that was carried out during the attachment was a fatigue study. The aim of this study was to test a fatigue monitoring algorithm, and see how effective it was. The RMS was used for this experiment, as it was an individual driver focused experiment. The participant was equipped with a 64 channel wet EEG system to measure neural activity. The participant was also monitored via an eye tracking system known as the SmartEye. The algorithm had proved to work in the laboratory without any problems, but it was devoid of motion simulation. Ultimately, the researchers want to deploy this algorithm into a system which can be used in theatre to monitor soldiers' fatigue levels. Arguably, the laboratory setting is very different from the real world. In the real world it is expected that there would be a lot more noise in the data, than was experienced in the laboratory. TARDEC provided the middle ground between a noise free lab environment and the real world. The RMS was expected to introduce new noise in the EEG data and the researchers wanted to see whether the algorithm would be robust against these new noisy data.

The participant had to complete two 45-minute drives, one with cruise control and one without. They were in a darkened room with minimal noise. The actual drive was very monotonous and boring. There were no distracters, and the road was empty and the surrounding environment very sparse. They were asked to keep the simulated vehicle in the centre of the lane. At the same time there were very slight random side forces trying to veer the vehicle away from the lane.

After the data was collected, it was handed over to the client. It was planned that the EEG data would be analysed to see if the algorithm could pick up areas where the participant was fatigued. This would be matched with the eyetracking video and the simulation run to see if the driver had actually deviated from the centre of the lane.

In the future, TARDEC plan to introduce more variables to the experiment, for example, emergency warnings or a convoy drive, to test whether the algorithm can filter through that type of extraneous noise and still predict when the driver is fatigued. Through this progression, it is hoped that the ultimate aim of this research, to one day introduce a fatigue monitoring device in theatre, can be achieved.

4.5 Other CASSI Labs

Apart from the motion base simulation labs, in the STTA, two other CASSI labs were visited. There were the N-Post Simulation laboratory and the Immersive Virtual Environment laboratory.

4.5.1 N-Post Simulator

The N-post simulator (Figure 8) has six posts, on which military vehicles, including tanks, can be placed. It is primarily used to do durability, stress, and force testing. It is a simple way to collect data for critical components such as suspension and wheels. After analysing the data, these components can be fine tuned in order to meet requirements. During the STTA, a new webbing structure was being tested. The webbing was placed on the sides of the vehicle, to see whether it could withstand normal operational forces.

The N-post simulator supports analysis of specific areas of the vehicles under larges forces or fatigue. The simulator is dynamic and the location of each actuator is easily interchangeable depending on the work requirements. It does not always need all six posts to do testing, as can be seen by Figure 8. Each post is capable of three degrees of freedom (3DOF) motion, in the linear motion axes, that is the x, y and z axes. An actuator is placed on each wheel location to simulate the shocks, vibrations, and motion each wheel is experiencing. For track vehicles the actuators are placed under each wheel spoke. Arguably the simulator handles wheeled vehicles better than the track vehicles, since the forces on track vehicles do not directly proceed to the wheels inside them.

The actuators for the simulator were designed by a company called MTS. MTS has provided both the hardware and software in a package known as Flex Test. This type of simulator is also used by car manufacturing industries to do similar durability, force, and stress studies. Industry tends to use a more advanced version of the TARDEC N-post simulator, which has the capability to do six degree of freedom (6DOF) motion on each post. Industry simulators also tend to have spindle characteristics on each wheel, which allows for each wheel to have independent acceleration profiles. However, industry simulators are several millions of dollars more expensive than the N-post simulator.

Figure 8: N-Post Simulator

4.5.2 IVE

The Immersive Virtual Environment (IVE) (Figure 9) can be used to simulate a wide range of three dimensional (3D) environments. For example, Figure 9 shows a group looking at a virtual mock up of a vehicle cabin. However, it can be easily transformed into an environment which enables soldiers to be exposed to highly dangerous and risky situations and allows them to decide on an appropriate course of action. It allows things such as planning, group decision making and other team dynamic issues to be analysed in a safe environment.

Figure 9: Immersive Virtual Environment

5. Other Agenda

During the attachment there was an opportunity to engage with another TARDEC division which is of interest to LOD. The attachment allowed a visit to the Army Research Laboratory – Human Research and Engineering Directorate (ARL-HRED). And there was also a chance to visit one of the software developers which TARDEC work closely with. This section will briefly summarise this other agenda.

5.1 ARL-HRED Visit

The Army Research Laboratory (ARL) has around 2280 staff, who are mainly scientists or engineers. Their main locations are in Maryland at the Aberdeen Proving Grounds, and the Adelphi Lab Centre. Their mission is to provide the underpinning science, technology, and analysis that enable full-spectrum operations. One of the divisions which TARDEC work very closely with, and which is of interest to LOD is the Human Research and Engineering Directorate (HRED). ARL-HRED has three broad roles, which are to enhance soldier performance and soldier machine interactions, provide human factors integration leadership, and use advanced simulation technology to increase training systems performance.

The soldier performance role includes cognitive and neuroscience research, which would ultimately improve a soldiers physical, perceptual, cognitive and psychological performance under hostile and highly stressed conditions. The human factors role is to ensure that soldier performance requirements are adequately considered in technology developments and systems design. The idea is that, in the future, soldiers are not given a piece of equipment or vehicle which considerably hinders their performance. The simulation and training role involves advancing simulation based capability, whether it be for training, experiments, analysis, or operational Army needs.

Currently one of ARL-HRED's main focuses is to evaluate different neurophysiology equipment. The team is examining five different types of EEG systems, to assess their potentials and limitations. They have the Advanced Brain Monitoring, the Bio Semi, Quasar, Mindo and Emotiv EEG systems (pictures in Appendix C). It was convincing to see that they obtained similar results from the Quasar systems as was found with the LOD study which Victor Demczuk ran in 2010. Sometimes the Quasar system appeared to work very well, and predicted mental workload accurately. However, at other times, it was clearly not working or was inconsistent.

ARL-HRED is also the group responsible for developing the IMPRINT software. IMPRINT stands for Improved Performance Research Integration Tool. It is used to help set realistic system requirements. It works by inputting task information into a predefined flow chart that measures the performance and accuracy for operational and maintenance missions. LOD has a copy of IMPRINT which has been used to model vehicle operator workload. Figure 10 shows a screenshot of IMPRINT.

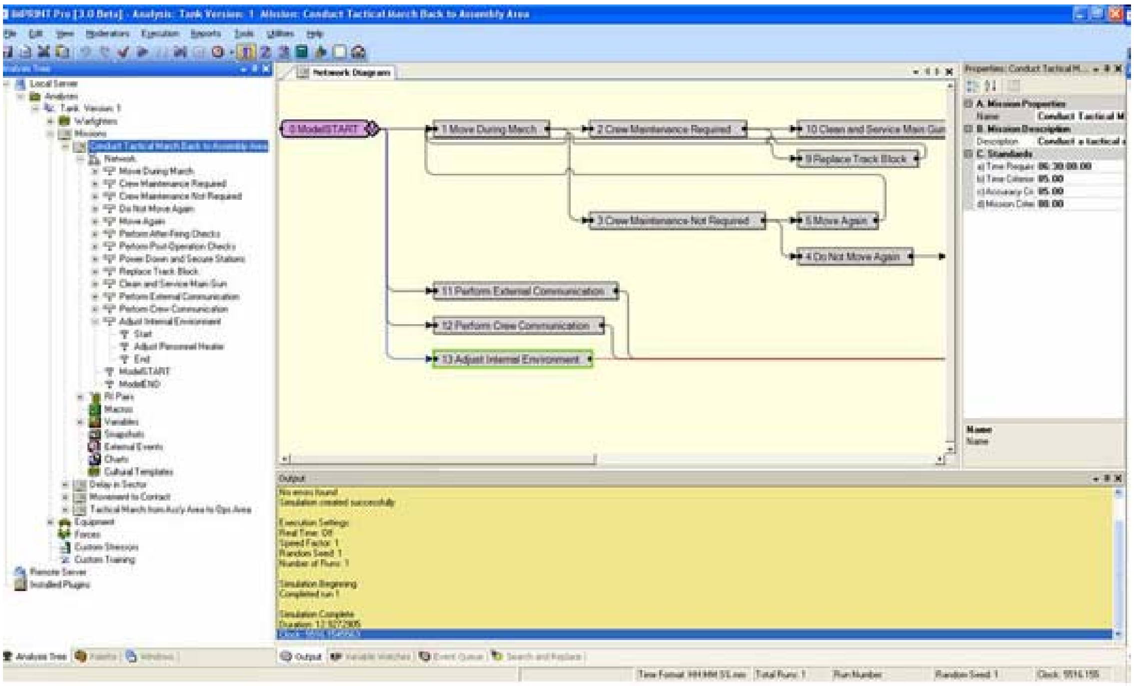

Figure 10: IMPRINT screenshot.

IMPRINT has four modules which can be used to do different types of analysis. The Warfighter module is used to estimate the type of individuals who will be available to operate and maintain a system. The equipment module is used to estimate the maintenance man-hours required to attain acceptable system availability. The Forces module estimates the manpower needed to complete the routine and unplanned work performed by a large unit. The most relevant module for LOD is the Missions module which is used to estimate the effect of operator performance on systems performance (time, accuracy, and/or mental workload effects).

During the visit, the main discussions were with Dr. Kelvin Oie, who is the neuroscience manager. The overlap between the respective organisations' research goals was realised and benefits of collaboration were discussed. It was envisaged that future experimental research could be shared amongst the two organisations, where the workload could be shared.

5.2 TARDEC Vehicle Electronics and Architecture (VE&A)

During the attachment there was also an opportunity to establish links with some other departments of relevance at TARDEC. There was a chance to have a face to face chat with Mr. Eric Bennett, who is one of the main leads for the VICTORY architecture. This area of research is very relevant to DSTO's VE&A team. Eric was keen to work collaboratively with DSTO in the Vehicle Electronics space. He also advised that the VICTORY architecture should be available to everyone, including international viewers by the end of January 2012[1].

The other group able to be contacted was the Power and Energy team at TARDEC. They are involved with many aspects of vehicular power and energy such as silent watch, space optimisation, energy efficiency and others. These are also issues that the LOD VE&A team is concerned about. A face to face meeting was not possible, but there was good email correspondence. The Power and Energy team also expressed their desire to work in collaboration with DSTO within those areas.

5.3 Realtime Technologies Incorporated

There was a one day visit to the Realtime Technologies Incorporated (RTI) office. The organisation was founded in 1998. They specialise in vehicle dynamics and graphics modelling. They can provide consulting with software applications, hardware development, and custom engineering solutions. Their lead product is SimCreator, which TARDEC have been using in both the CS/TMBS and the RMS.

TARDEC had evaluated other software consulting organisations, before choosing RTI to develop the simulation software. RTI's software is a real time dynamics model engine, which integrates various inputs to produce the necessary outputs to the motion base. SimCreator is a software package, similar to SimuLink. Most of the backend coding is done in C++.

RTI accounts for some common simulator limitations such as high yaw rates, or highly variable pitches. They also incorporate NATO standards, which define characteristics such as the speed limit that can be achieved over a particular terrain. They are capable of integrating other psycho-physiological tools into their software. For example, they have incorporated an eye-tracker into the software so that it can run seamlessly with the overall simulation. This integration allows questions such as, "where was the participant looking at this point in time", to be answered quickly and accurately. RTI continually have technical product version updates.

RTI have expressed their interest in developing any required software which we might require. They have worked with international clients in the past, and do not see distance as an obstacle. RTI are also relatively transparent with their coding, hence the user can modify the program to suit his/her needs.

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[1] VICTORY was made available to DSTO in July/August 2012.

6. Conclusion

The four month STTA was an excellent opportunity to collaborate with TARDEC and gain an understanding of how TARDEC has been effectively utilising motion simulators. TARDEC's many years of experience in the military land vehicle simulation space have lead to an acquirement of knowledge and skills which can be utilised in LOD's LAMP. The STTA provided an avenue to leverage off TARDEC's expertise in the area, and learn about some of the requirements and obstacles which face the LAMP.

The three major components which make up motion simulators (hardware, software, and network architecture) were all explored in the STTA. Strengths and weaknesses of the two TARDEC simulators were explored. Knowledge of the software and network architecture in place was also gained. The STTA was a chance to observe how TARDEC implemented the three key elements and why particular decisions were made. It was a chance to gather information about mistakes that were made in constructing and maintaining the facilities.

Different types of experiments were conducted on the CS/TMBS versus the RMS during the STTA. For instance, the RMS was used to evaluate a fatigue monitoring algorithm for a EEG system, and the CS/TMBS was used to conduct a 360 degree situational awareness study. Compared with TARDEC, the setup of LOD's motion simulation infrastructure is in its infancy. An understanding of the capability of TARDEC's two simulators can lead to better decisions for LOD in this area. For example, implementing the most effective software available will ensure a realistic simulation. Similarly, an optimal network architecture will lead to a seamless integration between the software and hardware. Continuing a close relationship with TARDEC can facilitate benefits for both the US and Australia (through data exchanges and sharing of experimental results) that may reap savings.

7. Recommendations

7.1 Hardware recommendations

If TARDEC had foreseen the crew studies which are currently being conducted on the CS/TMBS, it quite possibly would have chosen a different simulator, which would have provided more fidelity for human in the loop simulation. The CS/TMBS is very capable in carrying out its original purpose, but lacks some essential performance criteria for human experimentation. DSTO's LAMP can be classed somewhere between the CS/TMBS and the RMS, in terms of its performance specifications. It has a large cabin size, which can accommodate four people. This means that the visuals, motion cues, and audio cannot be optimised for everyone inside a cabin. Nonetheless, it is smaller and has a broader bandwidth compared to the CS/TMBS, suggesting that, it should perform better in crew studies compared to the CS/TMBS.

At the time of writing this document, LOD was in the process of acquiring another simulator, known as the CKAS V7. This was to be built by a company called CKAS Mechatronics, who are based in Melbourne. This motion base is much smaller than the LAMP and fairly similar to the RMS in terms of size and motion capability. It will at most be equipped with a double seater cabin, so all the cues can be optimised for either one person or two people. It will be a good addition to the division, as it will allow for focussed driving simulations to be optimised. The biggest advantage with this smaller simulator is that it has a bandwidth of 50 Hz. This means it should be able to recreate rough, off road military scenarios very well.

Today, there is a vast spectrum of simulators on the market, from robotic arm simulators to simulators that are on rails. Perhaps in the future these other simulators can be evaluated to see how it can benefit Defence. However, for the time being, the LAMP and CKAS simulators will provide DSTO with sufficient motion base capability to answer many of the human factors research questions under military driving conditions. Had the CKAS not been in the process of acquisition, there would have been a strong recommendation for a single seater, driver focused 6DOF simulator. But LOD's current direction in the simulation space is more focused on group rather than individual.

7.2 Software recommendations

For DSTO, it would be useful to adopt a similar approach to the software setup of TARDEC. A layered approach has flexibility in terms of identifying problems, incorporating different programs and gives high-quality simulation. For example if a single software ran the whole system, and the simulator goes into an emergency stop mode, it may be difficult to identify which component is causing the problem. The problem could range from the terrain, to the trigger point, to a user input. A layered approach would allow each component to be tested individually. Specialised software packages have there unique strengths, and those strengths are very difficult to replicate using a generic program which runs all components of a simulation. TARDEC's software approach is a proven system which has worked well with both simulators.

It is not suggested that LOD simply go with exactly the same software packages that are used by TARDEC, but it would be beneficial to incorporate their software infrastructure. There are different software packages which are available for different aspects of the simulation. For instance, there are many terrain modelling software and scenario creation software packages available on the market. It would be a good idea to evaluate the available tools on the market before choosing particular ones.

It would also be advisable to have the LAMP controller software sit outside the main software setup, as this is critical to the safety of the system. The emergency measures should be kept in isolation from all other software being used by the system.

7.3 Managerial recommendations

Creating realistic and accurate simulation scenarios requires a large amount of effort and a diverse range of applied skills. It requires constantly improving from the previous experiment, as well as developing new scenarios depending on the research question. It is understandable that such advanced technology functions require an extensive team.

The LAMP has similar capabilities to the CS/TMBS. Both simulators currently have a cabin capable of carrying four people. They both will be used to simulate military vehicles in several different terrain types. Neither simulator was obtained for the purposes of training military drivers. Rather, these simulators will be used to conduct various experiments which will require a team to navigate a vehicle under motion. However, the drivers inside these simulators must receive a sense of realism or the use of motion would be redundant. Just like the CS/TMSB, the LAMP will require a vehicular physics engine, an interactive terrain model, appropriate audio and visual cues and associated hardware (e.g. emergency interventions, steering and acceleration inputs, etc.). TARDEC has addressed all these aspects in order to conduct end user experiments such as those focussing on situational awareness and fatigue (details in Section 4.4). LOD will also aim to address the same simulator aspects in order to conduct similar experiments. For instance, there is a plan to conduct the usability of a Battle Management System and a fatigue experiment soon after the completion of the LAMP.

Due to the large similarities and overall purpose between the two simulators, it is strongly recommended that a dedicated team be involved with running, maintaining, and managing the LAMP. If the LAMP is to be utilised effectively, a similar team such as in Table 2 (pg 20) is most likely required. At the very least, it is envisaged that this type of team would be required during high workloads on the LAMP (e.g. during/leading up to experiments). If unable to meet such criteria, the LAMP could be at risk of being underused and poorly managed.

The one area which perhaps does not require full time staff to be dedicated to the LAMP, is the vehicle dynamics modelling. If LOD were to employ a contractor to do the dynamics modelling of a specific military vehicle, then this model could possibly be used for a substantial amount of time. Unless, there is a specific need to model a different vehicle, then a general vehicle model could be used for multiple experiments. However, to add to the realism, it is recommended that a correct dynamics model for a current in service vehicle (e.g. Bushmaster) be done accurately.

Appendix A: RMS Simulations

Figure 11 is an unclosed cabin which TARDEC had before the RMS has covered. Figure 12 is a computer simulation environment from one of their past experiments. Figure 13 shows a participant driving in near darkness and being monitored via night vision cameras. Figure 14 shows a participant undertaking an experiment being monitored by an eye tracker.

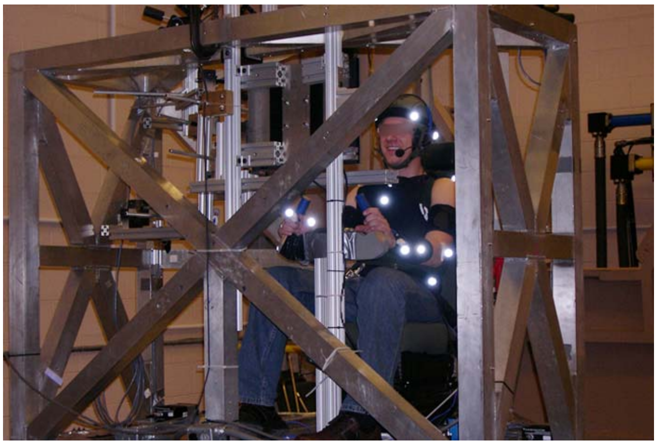

Figure 11: RMS setup as of its original design.

Figure 12: Typical simulation scenario through which a participant might drive during an experiment.

Figure 13: Participant completing a mission in darkness, whilst being monitored by a night vision camera.

Figure 14: Eye tracking whilst completing a mission

Appendix B: Contacts information

NB: Contact details are correct as at 1 December 2011.

TARDEC employees

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Mr. Christopher Mikulski (TARDEC, MBT): Christopher.m.mikulski.civ@mail.mil
Mr. Tom Mikulski (TARDEC):
Dr. Alexander Reid (TARDEC, MBT senior engineer): alexander.a.reid.civ@mail.mil
Mrs. Jennifer Hitchcock (TARDEC, senior leadership)
Mr. James O'Kins (TARDEC, mech eng): james.okinsl@us.army.mil. Used to work in Harry's team, but now works in the physical simulation team.

TARDEC contractors

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Mr. Todd Mortsfield (DCS Corporation):

ARL-HRED

Dr. Kelvin Oie (ARL-HRED, Neuroscience Manager): kelvin.s.oie.civ@mail.mil
Dr. Kaleb McDowell (ARL neuroscience leader).

Others

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Mr. Robert Genkinger (independent consultant): rgenkinger@yahoo.com. Lead MRAP 360 SA experiment.
Mr. Pete Swan (VT MAK, business developer): pswan@mak.com
Dr. Jonathon Bornstein (ARL, robotics)

Appendix C: ARL-HRED Current Research

One of the areas of research which ARL-HRED is currently undertaking is the evaluation of different EEG systems. Below are the five systems that are being assessed.

Figure 15: Advanced Brain Monitoring EEG

Source: http://advancedbrainmonitoring.com/advwp/neurotechnology/wireless-eeg/b-alert-x24. Retrieved March 13 2012.

Figure 16: BioSemi EEG

Source: http://www.biosemi.com/pin_electrode.htm. Retrieved March 13 2012.

Figure 17: Quasar EEG

Source: http://www.quasarusa.com/products_dsi.htm. Retrieved March 13 2012.

Figure 18: Mindo EEG

Source: http://www.quasarusa.com/products_dsi.htm. Retrieved March 13 2012.

Figure 19: Emotiv EEG

Source: http://www.emotiv.com/about/media. Retrieved March 13 2012

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19. ABSTRACT
In late 2011 a Land Human Scientist (LHS) from the Land Operations Division (LOD) was briefly deployed to the Tank Automotive Research Development and Engineering Centre (TARDEC) to collaborate and gain understanding of how TARDEC is effectively utilising motion simulators. TARDEC has been conducting motion simulation research in the military land vehicles domain in excess of twenty years. At the time of the deployment, LOD was in the process of building its own motion simulation capability through the purchase of a large six degree of freedom LAnd Motion Platform (LAMP). The main purpose of the training attachment was to acquire knowledge and skills with motion simulators so it could be applied to the LAMP. This document summarises the approaches taken by TARDEC with its motion simulation setup, why particular decisions were made, and makes recommendations for the LAMP.

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